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Application for Patent

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אני, (שם המבקש, מענו -- ולגבי גוף מאוגד -- מקום התאגדותו)
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INFRA-RED LIGHT SOURCE

מבקש בזאת כי ינתן לי עליה פטנט
hereby apply for a patent to be granted to me in respect thereof

*בקשה חלוקה - Application for Division	*בקשת פטנט מוסף - Application for Patent of Addition	*דרישה דין קדימה Priority Claim		
מבקשת פטנט from Application	*לבקשה/לפטנט to Patent/Appl.	מספר/סימן Number/Mark	תאריך Date	מדינת האיגוד Convention Country
No. מס.	No. מס.			
dated מיום	dated מיום			

*יפוי כח: כללי/מיוחד - רצוף בזה / עוד יוגש
P.O.A.: general / individual - attached / to be filed later -
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C:34113

This היום 8 of בחודש JUNE of the year שנת 1999

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מתקן אור אינפרה-אדום

INFRA-RED LIGHT SOURCE

INFRA-RED LAMP SOURCE

FIELD OF THE INVENTION

The present invention relates in general to the field of infra-red radiation sources, and in particular to sealed-off molecular gas discharge sources.

BACKGROUND OF THE INVENTION

The technology underlying the operation and production of electrode-less cold gas discharge infra-red lamp sources has been described in U.S. Patent No. 5,300,859, entitled "IR-Radiation Source and Method for Producing Same" to S. Yatsiv et al., hereby incorporated by reference. One of the important advantages of such lamp sources is that they emit very narrow spectral lines at discrete frequencies characteristic of the molecular rotational-vibrational to ground state transitions of the excited gas species contained in the lamp. This is achieved in a source which is sealed-off, is compact, has a good level of conversion efficiency from electrical to optical power, and has a long life compared with previously available sealed-off lamps sources.

Because of their unique spectral properties, such lamps have been widely used as sources in non dispersive infra-red (NDIR) spectrometry instruments, and especially in gas analyzers for use in medical applications. The narrowness of the emission lines provides such gas analyzers with high levels of selectivity, sensistivity and stability, which are many times better than gas analyzers of similar complexity, which use alternative technology sources, such as hot blackbody sources. The other advantages mentioned above enable the production of compact and cost effective instrumentation using such sources.

The lamp sources described in U.S. Patent No. 5,300,859 have found particularly advantageous applications as sources of the CO_2 spectral emission lines, for gas analysis of exhaled breath, to determine the levels of CO_2 therein.

Such CO_2 sources have been used to great advantage in capnography and breath testing instrumentation. Since the mechanisms and dynamics of the electrical excitation of CO_2 and of its ensuing spontaneous emission spectrum are essentially identical to those used in carbon dioxide lasers, there exists a very large body of knowledge and prior art concerning this technology.

In U.S. Patent No. 5,300,859, there is a thorough discussion regarding the parameters affecting the lamp emission rise and decay time, efficiency, excitation and output, and the lamp lifetime as a function of chemical methods used to clean the lamp before sealing. The patent does not relate at all, though, to the spectral stability of the lamp source. However, when used as a frequency selective source in NDIR spectroscopic applications, spectral stability is even more important than the above parameters. Output changes over time can easily be monitored and corrected by using a reference path, since it is a single value correction. On the other hand, spectral changes can not be easily monitored or corrected for, because there is virtually infinite information in a spectrum. Changes in the lamp spectrum cause changes in the absorption cell absorption characteristics. If these changes are not known, then it is impossible to accurately measure gas concentrations using such lamp sources.

There therefore exists a serious need for a method of maintaining the spectral stability of electrode-less cold gas discharge infra-red lamp sources of the type described in U.S. Patent No. 5,300,859.

The disclosures of all publications mentioned in this section and in the other sections of the specification, and the disclosures of all documents cited in the above publications, are hereby incorporated by reference.

SUMMARY OF THE INVENTION

The present invention seeks to provide a new method of producing cold gas discharge infra-red lamp sources with improved spectral stability, especially those operating with a carbon dioxide fill. A number of factors affect the spectral

stability, such as temperature, electrode position and time. The first two are factors of the operating conditions and geometry of the lamp, and if well understood, can be well controlled.. The changes over time are much more problematic, since they are due to long term changes in the composition of the gas fill. It is thought that a major cause for long term changes in the lamp output and spectrum is the result of the gradual break down of carbon dioxide into carbon monoxide and oxygen. In the first few minutes of lamp operation, an equilibrium of the above molecules is reached, but over time this equilibrium level changes as CO and O_2 are adsorbed on the walls of the lamp envelope. Impurities also reduce the CO_2 level still further.

Up to now, the prior art has been primarily concerned with the change in power output which occurs as the CO_2 level changes. This is particularly so because of the importance of maintaining power levels over time in sealed-off CO_2 lasers. However, the changes in CO_2 concentration also affect the spectrum since the CO_2 molecules in the lamp not only emit radiation, they also absorb radiation. The lamp itself operates as an absorption cell to the emitted light passing through its gas fill to the output window. The CO_2 lines are absorbed at their centers, and their shapes thus change in a process known as self-absorption.

Even the Doppler broadened lines emitted from the lamp are much narrower than the absorbing lines in a gas sample at atmospheric pressure. As a result, the region of coincidence on the absorbing lines is of approximately constant magnitude. Hence, there is no change in absorption characteristics for any individual emission line for different degrees of self- absorption, but the change in the distribution of the individual line intensities will cause an overall change in the absorption characteristics. As a result changes in self-absorption create a change in the emitted line strength distribution of the first order band group. i.e. the weaker absorbing lines of the Boltzman distributed intensities traverse the lamp with little attenuation, even in the presence of the high CO_2 concentrations inside the lamp, but the strongly absorbing lines of the Boltzman distributed intensities are strongly attenuated.

These changes in line intensity distribution are similar in their effect on the absorption characteristics to those changes in distribution resulting from changes in relative group/order (isotope) strength or Boltzman distribution changes resulting from changes in temperature.

Expressed mathematically:

The lamp output radiation after absorption in the gas cell given by:

$$I = \Sigma e^{-\alpha 1jdc} I_{1j} + \Sigma e^{-\alpha 2jdc} I_{2j}$$

where I_1 and I_2 are for the first and second order respectively, and are defined over their line intensities I_{nj}. This relationship follows from the Beer Lambert law.

Defining a distribution ratio $X = \Sigma I_{1j} / (\Sigma I_{1j} + \Sigma I_{2j})$ (the output ratio between first and second order of line distribution j).

Then the transmission $t_{(c)}$ is given by $t_{(c)} = t_{1(c)} X + t_{2(c)} (1-X)$ for any given concentration c.

When the lamp CO2 concentration changes with time, this distribution ratio changes and hence the absorption characteristics of the optical system consisting of the emitting lamp and the absorbing cell.

Although self-absorption can be anticipated from theory, it is difficult to demonstrate directly. This is mainly because the typical line width for the lamp is less than 0.006cm-1. Only an FTIR instrument with at least a 2 meter mirror movement is capable of resolving such a narrow width. The self absorption fine structure is even more difficult to resolve.

An FTIR instrument with the optimum resolution currently attainable was used to capture the effect. Comparisons between aged and new lamps for changes in line shape clearly show the effect. Other effects such as changes in Boltzmann distribution or changes in the ratio of first and second order lines, were negligible in comparison.

There is thus provided in accordance with a preferred embodiment of the present invention, a method for increasing the spectral stability of cold gas discharge infra-red lamp sources, by the use of a catalyst to reduce the changes with time in the level of the active emitting gas molecules in the lamp, thus resulting in a reduction in the changes in self-absorption. It is known that the use of catalysts encourages the recombination of dissociation products of molecules broken down under the effect of electrical discharges, to reproduce the parent gas molecule from which they originally dissociated. To the best of the Applicant's knowledge, catalysts have never been used or suggested for stabilize the emission spectra of gas discharges over long periods of time.

In the case of the CO_2 discharge, the CO and O_2 molecules within the lamp envelope can be recombined under the influence of suitable catalysts, to reform the CO_2 molecules from which they dissociated. It is well known from the art that in sealed-off laser technology, such catalysts are used to maintain the level of CO_2 in the laser cavity, in order to prevent a decay in the laser power output, which would occur if the percentage of dissociated CO_2 were to increase with time. One example of such a catalyst is described in U.S. Patent No. 4,756,000, to J. Macken, entitled "Discharge Driven Gold Catalyst with Application to a CO_2 Laser". However, the technology described therein is aimed exclusively at maintaining the laser gain, the laser efficiency and power output level of the emission from the laser discharge, and no mention was made, nor was any interest even suggested, that the catalyst be used to maintain the spectral stability of the discharge.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A number of catalysts are known for reproducing CO_2 from CO and O_2 , such as platinum with tin oxide, sputtered gold and silver coatings. The method of providing the catalytic coating on the interior of the discharge lamp envelope, in order to increase the lamp's spectral stability, depends on the material used for

the catalyst. According to one preferred embodiment of the present invention, the method consists of sputtering the gold in a finely divided form onto the inside of the lamp envelope, such that it forms a non-conducting film, with a very high surface to volume ratio. Other metals such as Iridium, Rhodium, Palladium and Nickel can also be used as catalysts.

Since the catalyst reduces the breakdown of CO_2, it is possible to produce a miniature lamp, without the need for a large ballast volume of gas. Such a lamp is advantageous for use in portable systems. Such a smaller lamp has a better surface to volume ratio with respect to the active media and the activated O_2 molecules require a shorter path length to reach the coating, and hence have a higher probability of reaching the catalytic coating in the required activated state. In U.S. Patent No. 5,300,859, lamp volumes of the order of 60 ml. were disclosed. This volume was required to ensure an adequate resevoir volume to ensure long lamp life. According to the present invention, lamp volumes of 20ml or less are sufficient to provide similar lifetimes while maintaining spectral stability.

Since the catalyst reduces the breakdown of CO_2, it is feasible to produce a lamp with an initial low CO_2 pressure. In U.S. Patent No. 5,300,859, CO_2 percentages of the order of 10% are recommended for optimum output and lifetime considerations. According to preferred embodiments of the present ivention, minimum CO_2 concentartions are preferred in the lamp gas mixture, for minimal self-absorption. This provides very deep absorption curves, permitting use of a shorter cell path.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of various features described hereinabove as well as variations and modifications thereto which would occur to a person of skill in the art upon reading the above description and which are not in the prior art.

CLAIMS

We claim:

1. A method for constructing an electrically excited cold gas discharge lamp, including the steps of:

constructing a lamp envelope;

cleaning said lamp envelope;

filling said envelope with a gas mixture; and

characterized by the additional step of including a catalytic material within said lamp envelope.

2. The method according to claim 1 wherein said catalytic material is coated on an inside wall of said envelope.

3. The method according to claim 1, wherein said catalytic material is chosen from a group comprising gold, silver, rhodium, iridium, palladium, platinum and nickel.

4. The method according to claim 1, wherein said catalyst is operative to increase the spectral stability of said lamp.

5. The method according to claim 4, wherein said increase in the spectral stability of said lamp results from a reduction in the level of self-absorption in said gas mixture.

6. The method according to claim 1, wherein said lamp volume is less than approximately 20 milliliters.

7. The method according to claim 1, wherein said gas mixture contains carbon dioxide.

8. The method according to claim 8, wherein the concentration of said carbon dioxide is less than approximately 5%.

9. A method according to any of the preceding claims and substantially as shown and described hereinabove.

For the applicant:

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